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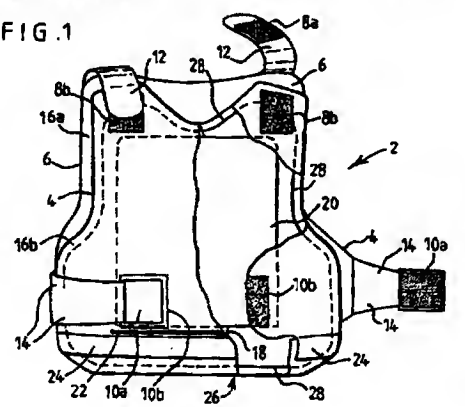
(54) Abstract Title
Protective Garment

(57) A Protective garment (2) comprises a plurality of ballistic-resistant textile layers and an outer surface of a layer of knife resistant mesh. The mesh may be gathered, made of metal or ceremic material and may comprise interengaged endlese links. The ballistic-resistant layers may be contained in two or more packs (20), where e plurality of the layers ere tightly secured together in each pack, and the packs ere loosely secured together. A Treuma reduction peck mey also be provided, which may comprise a layer of small-celled foam and a layer of flexible plastics sheet, which may be of low density polyethylene. Tha garment may comprise an outer cover (16) adapted to be worn by the user heving one or more pockets (18)for housing packs of protective material which meet different standards of body armour. The garment may also include a thin plastics layer to resist needle penetration.

FIG.1



GB 2 342 278 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

FIG.1

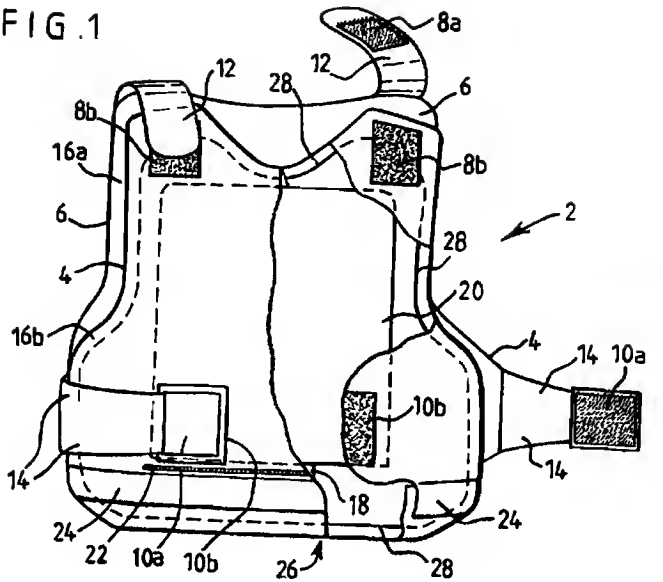
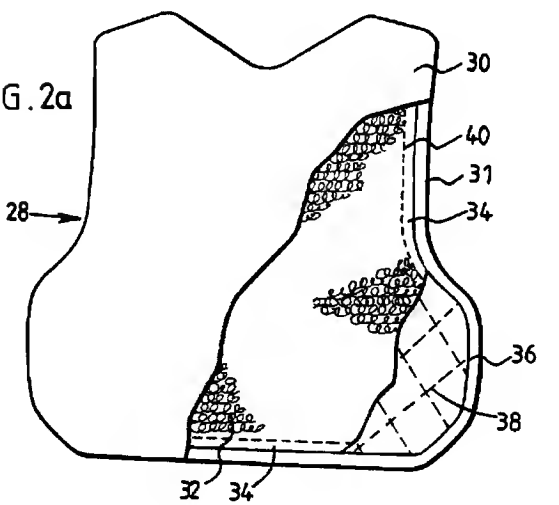

8a
12
12
28
6
8b
16a
8b
6
2
28
4
20
16b
4
14
10a
10b
14
14
18
24
24
22
10a
10b
26
28

FIG.2a


30
40
31
34
28
36
38
32
34

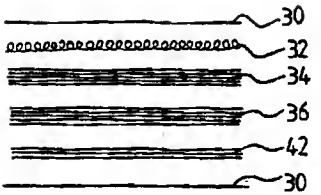


FIG.2b

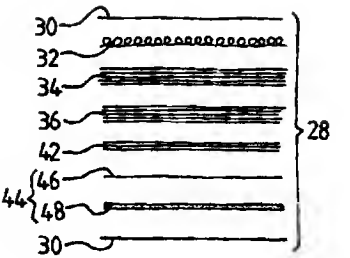


FIG.2c

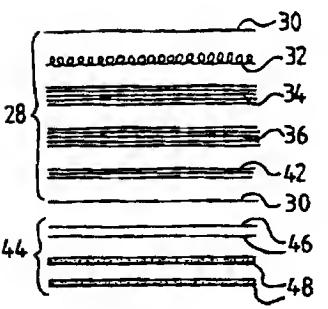


FIG.2d

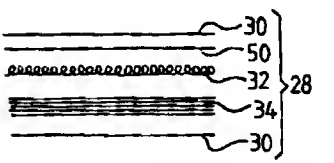


FIG.2e

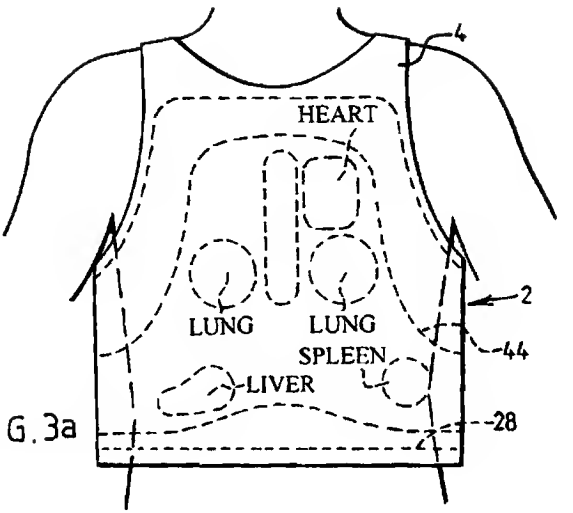

4
HEART
LUNG
LUNG
2
SPLEEN
44
LIVER
28

FIG.3a

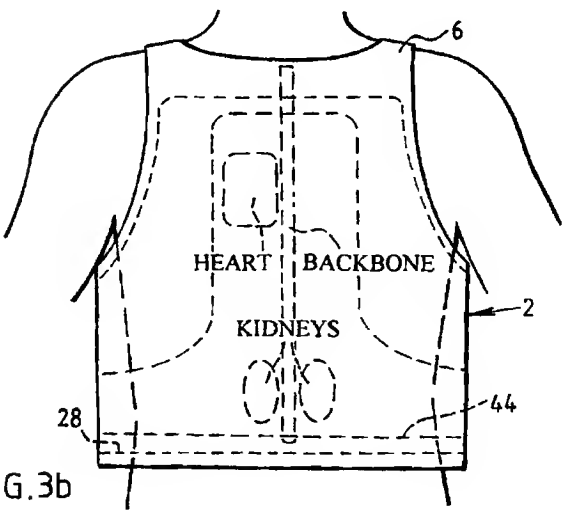

6
HEART
BACKBONE
2
KIDNEYS
28
44

FIG.3b

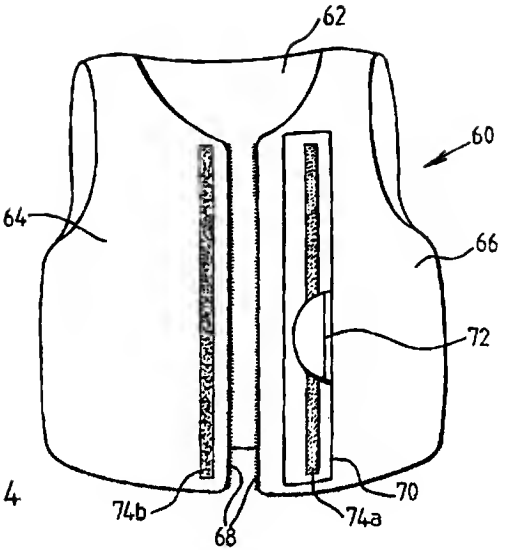

62
60
64
66
72
70
74b
74a
68

FIG.4

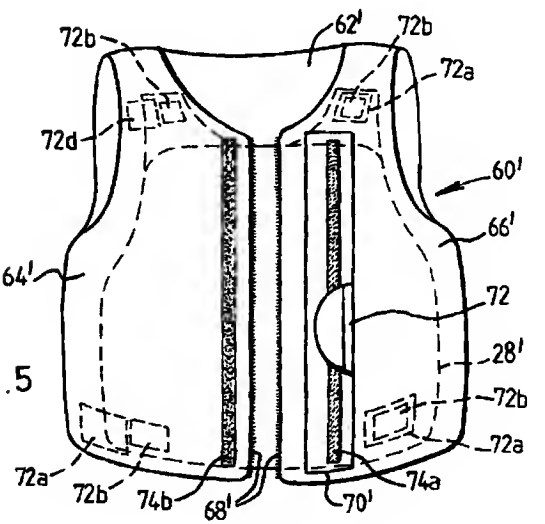

72b
62'
72b
72a
72d
60'
66'
64'
72
28'
72b
72a
72a
72b
74b
68'
70'
74a

FIG.5

Protective Garment

The present invention relates to a protective garment or "body armour", such as a bullet resistant vest. Such garments are required to fill a variety of requirements: to resist penetration by ballistic threat, such as bullets, and by sharp edged weapons and stabbing, and to protect against trauma caused by blunt instruments, for example baseball bats. The need for many workers, especially military and police, to wear protective garments is widely accepted. However, there are instances where the garments are not worn because they are too uncomfortable - too heavy or too hot - or because they are thought to hinder the movement of the wearer. Thus, there is a constant need to improve the available designs of protective garment, especially for females.

It is known to provide range of protective garments offering various levels of protection. Some facility for temporarily up-grading protection is also known, for example providing a pocket to receive a metal or ceramic plate to prevent penetration by a high velocity bullet. However, most employers can stock only a limited range of protection for employees because of the costs involved, and so protection is not easily tailored to the prevailing conditions or risk. This may mean, for example, that a higher grade, and inevitably less comfortable, garment must be worn, or that too low a grade of protection is worn.

A typical protective garment comprises several layers of closely woven aramid (RTM) fibre for protection against lower velocity bullets, such as from a hand gun. Curiously, these do not offer adequate protection against penetration by a knife. Chain mail or metal mesh has long been used in butchers aprons and gloves for protection against accidental cuts.

WO97/24574 interleaves a layer of metal mesh - ceramic or metal chain mail - between two packs of woven aramid fibre layers.

We have found that the resistance to penetration by sharp edged objects or weapons, such as a stabbing action with a knife, can be substantially improved by providing a layer of chain mail on a front surface only of the woven aramid fibre layer pack.

Thus, a first aspect of the present invention provides a protective garment comprising a plurality of fabric layers resistant to penetration by a projectile such as a bullet and, on the outer surface of the plurality of layers relative to the wearer, a layer of knife resistant mesh.

Very preferably the mesh is attached to the fabric so as to be slightly gathered or baggy. It has been found that this significantly improves the resistance to penetration by a knife blade used in a stabbing action. Without being bound by theory, it is believed that the mesh will wrap around the blade to slow its penetration. The mesh is typically of metal or ceramic material of sufficient gauge to resist cutting during a typical knife attack, and comprises interengaged links, such as in chain mail.

Preferably the mesh is attached at its outer perimeter to the fabric layers, and a short distance in from the edge of the layers. Preferably the mesh is gathered by about 5 to 10 per cent of its length in at least one direction. To even out the sagging of the mesh, it may be tacked to the textile pack at intervals across its area. This may be done by stitching, but preferably is done by adhering it with a mastic composition.

Typically the woven fabric layers are of aramid fibre but other ballistic resistant textiles may be used.

US-A-4 608717 describes a basic protective armour in which an inner unit is formed by a layer of feathers, foam or the like sandwiched between two packs of aramid fibre layers, the layers of the whole pack being drawn tightly together by stitching. An additional outer unit of aramid fibres is stitched at its periphery to the outer surface of the inner unit to provide

increased penetration resistance while retaining flexibility of the finished pack.

We have found that by subdividing a pack of aramid fibre layers into a plurality of packs, greater penetration resistance is achieved.

Thus a second aspect of the invention provides a method of manufacturing a protective garment, comprising subdividing into two or more packs a number of fabric layers providing resistance to penetration by a projectile such as a bullet, the layers of a pack being tightly held together, thereby to provide increased penetration resistance. Preferably the packs are attached together only loosely. Thus, we have found that two packs, one of eleven layers and one of ten layers, each set of layers held tightly together by stitching, provides greater penetration resistance that a single pack of twenty-one layers. Further sub-division of a pack may provide more penetration resistance, but will add to the manufacturing cost.

Woven aramid fibre fabric will slow and deflect the travel of a low velocity bullet to prevent penetration of the body. However, the impact from even a low velocity bullet will result in considerable trauma to the body as the bullet deforms the fibre packs and the force of the impact is localised in the region of deformation.

Thus, various trauma standards set the degree of back face deformity which is considered allowable and trauma reduction arrangements are provided in the art. GB-A-1 556 245 describes the use of an impact absorbing polycarbonate and/or foamed plastics layer. GB-A-2 258 389 also use a foamed plastics and/or polycarbonate for impact absorption. GB-A-2 231 481 describes a contoured semi-stiff sheet for distributing the shock.

A third aspect of the present invention provides a trauma reduction arrangement in a protective garment, comprising a layer of small-celled foam and a layer of low density polyethylene (LDPE). The foam layer is positioned, in use, closest to the wearer, and the LDPE is positioned between the foam and the outer penetration resistant layers. The foam and

the LDPE may be adhered or otherwise attached to each other, but preferably they are not.

A plurality of LDPE layers and/or a plurality of foam layers may be used. Preferably the LDPE layers are 0.3 to 0.7 mm thick, and preferably about 0.5 mm thick. The foam layers are preferably about 2 to 6 mm thick and preferably about 3 mm thick.

The prior art has noted the desirability of retaining flexibility as the protective layers are built up, e.g. in US-A-4 608 717 noted above. US-A-4 774 724 notes that the trauma pack, typically comprising a relatively stiff polycarbonate layer, inhibits flexibility. Thus, US-A-4 774 724 suggests attaching a trauma pack to an otherwise finished garment to up grade the protection afforded by the garment. The trauma pack may be shaped and positioned to protect only a limited area, such as the heart region. A difficulty of this arrangement is that the trauma pack is not seen by the user as being an important part of the garment, and so may be left off by insufficiently trained personnel who see it as only preventing bruising, rather than as upgrading the protection level of the garment, and also the garment cannot be properly tailored to provide a good, comfortable fit both with and without the trauma reduction pack in place.

We have appreciated that the primary aim of trauma reduction is to prevent serious, life threatening damage to the body, and to prevent incapacitating injury. Thus, trauma reduction is required only by limited areas of the body, and that by providing the trauma reduction pack or layers in those areas only, it is still possible to provide a comfortable garment having the required degree of protection.

Thus a fourth aspect of the present invention provides a protection garment comprising an extensive penetration resistant layer for resisting penetration by a bullet or the like, and a trauma reduction layer which is not co-extensive with the penetration resistant layer. In particular, the trauma reduction layer covers regions where vital organs are close to the surface of the body.

As mentioned above, US-A- 4774 724 suggest the use of a removable trauma pack to temporarily upgrade the degree of protection when required. We have realised that this concept, coupled to our realisation that multiple packs of woven fibre layers can provide enhanced protection over a single pack having an equal number of fibre layers, can provide the user with a very adaptable and flexible protective garment system.

Thus, a fifth aspect of the invention provides a protective garment system comprising:

a garment outer cover adapted to be worn by a user, the cover having one or more pockets for housing a pack of protective material,

a first pack of protective material adapted to meet a first standard for body armour, and

a second pack of protective material adapted to meet, alone or in combination with the first pack of material, a second, higher standard for body armour.

Thus, the supplier, employer or wearer may carry a selection of packs of protective material. The packs are replaced or used in differing combinations to provide a level of protection which is suited to the risk assessment of the prevailing or perceived threat. Thus, a wearer is not obliged to wear a protective garment which is over-specified for the risk assessment (and hence unnecessarily heavy or stiff, etc.) or tempted to opt for an under-specified level of protection because the optimum is not available.

In a simple arrangement, a basic pack is used, and additional packs are provided to increase protection to the next prevailing standard of protection.

Thus, for example, packs may be provided which incorporate ballistic resistant textile materials. The first pack may meet a first protection standard and a second pack in combination with the first may meet a second, higher standard. One of the packs could be a trauma reduction pack.

Police and security personnel are increasingly at risk from attack with hypodermic needles. Needles can penetrate woven material, such as the ballistic resistant woven aramid fiber. They can also penetrate the preferred LDPE layer we use for trauma protection when it is placed behind the ballistic fibre layers (i.e. closest to the wearer). A rigid layer, such as polycarbonate, may provide protection, but lacks flexibility and so can give rise to innocuous risk. For example, a rigid layer in the garment could result in neck injuries to situations where the garment is caused to ride up the wearer's body. We have found that a thin flexible plastics layer, preferably a polyvinylchloride, PVC layer, typically about 0.15 mm to about 1.0 mm thick, can provide protection against needle penetration. Very preferably the layer is positioned at the front outer surface of the pack or packs of other protective material so that the ballistic fibre weave, for example, does not form a channel supporting the needle. More preferably, a plurality of thinner layers is used, typically 3 to 8 layers giving a total thickness less than 1.0 mm. The PVC layer may be provided as overlapping plates to allow greater flexibility, for example at elbow joints.

The invention will be further described by way of example, with reference to the accompanying drawings, in which :

Figure 1 shows a first embodiment of a protective garment in accordance with the invention, partly cut away;

Figures 2a to 2e illustrate the structure of protective packs for the embodiment of Figure 1;

Figures 3a and 3b illustrate a second embodiment of the invention using a zoned trauma protection system;

Figures 4 and 5 show embodiments of waistcoats in accordance with the invention.

Figure 1 shows a protective garment 2 in the form of a vest for protecting the upper torso. It will be appreciated that the vest is provided in difference sizes, and with some variation of shaping to suit men and women.

The garment 2 has front and back panels 4, 6 which are attached to each other by hook and loop fasteners 8, 10 such as VELCRO (registered trade mark). Shoulder straps 12 on the rear panel 6 carry the hook portion 8a for engaging with the loop portion 8b of the fastener 8, allowing some adjustment in the shoulder region. The waist fitting is by means of straps 14 on the rear panel 6.. The straps 14 are attached to a respective panel 10a of hook material and engage a panel 10b of loop material on the front panel 4. The front and back panels 4, 6 are shaped to ensure overlap at the side of the torso. The straps 14 may be elasticated to provide increased comfort.

The garment 2 can be provided for wearing underneath a shirt or blouse, in which case the outer cover 16 of the panel 4, 6 is preferably of white cotton or polyester material When worn outside the shirt or blouse, the outer cover 16 may be coloured to suit the user. The inner cover layer 16a adjacent the wearer's body is preferably of breathable material such as COOLMAX (trade mark) to provide a system of sweat management.

The outer covers 16 form pockets for carrying packs of protective material, as will be described hereinafter.

On the inside surface of the outer layer 16b of the front and back covers 16 a pocket 18 is formed to receive a ballistic insert panel 20 as is well known in the art. The panel 20 is typically of metal or ceramic and is used to provide protection against high velocity bullets. A zip fastener 22 provides access to the pocket 18.

The inner and outer cover layers 16a, 16b, together form a large pocket for receiving the packs of protective material which form a particular feature of this invention. Access to the pockets is via a flap 24 at the bottom edge 26 of each panel 4, 6 which is closed by a hook and loop fastener.

On the inside surface of the cover outer layers 16b, hook or loop fasteners are provided to locate the packs of protective material which carry complementary fastener parts.

Apart from the variation of size and overall shape to suit different wearers, a degree of tailoring may be introduced to provide better fit and comfort. Thus, darting may be provided at the sides of the chest area, and from the waist up to the chest. This can also aid flexibility and is particularly useful for providing a better fit to the female breast area which is particularly sensitive to impacts.

Figure 2a illustrates a protective pack 28 in accordance with the invention. The pack 28 has a waterproof outer cover 30 which is heat sealed around its edge 31. A breathable waterproof material, such as GORETEX, BELLAIR and No. 3 grade NOMEX (trade marks) may be used. Within the cover 30 are provided a layer of chain mail or metal mesh 32 and two packs 34, 36 of ballistic textile layers.

The ballistic resistance of a pack of ballistic textile layers depends on the textile itself, the weave of the fabric and the make-up of the pack. The commonly used fiber is an aramid fiber such as TWARON (RTM) from AKZO and KEVLAR (RTM) from DuPont DYNEMA from Dynema and GOLDFLEX from Allied Signals.

The number of layers in a pack will depend on the fibre and the weave. It is believed that the ballistic resistance depends on, inter alai, the strength of the individual fibres, the number of fibres or picks per inch and the number of fibre cross-overs. Thus, different fibre types and weaves may allow or require a lower or higher number of textile layers.

In determining the number of layers we place in a pack, we have regard to flexibility, as well as ballistic resistance. Thus, if twenty-one layers are needed to meet the required standard, this can result in a relatively inflexible pack. Hence, we prefer to divide the layers between two packs of, say, ten and eleven layers each. We have found this can result in increased ballistic resistance.

In this embodiment we use a basic pack of eleven layers of polyaramid fibre material (TWARON C T 709 from Akzo Nobel, which has a thickness of about 0.3 mm and a weight of 200 gm per square metre).

Preferably a pack contains between 5 and 15 layers, more preferably about 8 to 12 layers of the ballistic fabric. The overall pack thickness is preferably from about 1 to 5 mm, more preferably about 2 to 4 mm and preferably about 2.5 to about 3.5 mm. A pack of textile layers is typically held together by quilt stitching - diagonally crossing stitch lines at about 30 to 60 mm intervals. Thus, in this embodiment the pack 36 is made up of eleven layers of plain weave TWARON fiber which are held together by quilt stitching at about 30 mm intervals by stitch lines 38. A second pack 34 is made up of ten layers of plain weave TWARON CT709 which are quilt stitched together. The two packs are then held together by perimeter line of stitching 40 so that there is some flexibility and pocketing between the packs.

As well as providing better performance as compared to a single pack of 21 layers, the two pack design also provides a less rigid construction, and hence increased comfort. It is believed that in principle more packs of fewer layers each, for example, 5, 5, 5 and 6 would provide more improved performance, however, costs of manufacture will increase.

A further benefit of using multiple packs is that it facilitates the manufacture of garment meeting different required levels of ballistic protection. Thus, in the example described a pack of 11 layers of TWARON CT709 is chosen to meet a first, lowest level of ballistic protection set by, for example, the United States National Institute of Justice, and the addition of the second pack of 10 layers giving a total of 21 layers, results in a design which meets the second level of ballistic protection of the NIJ. A further pack or packs can be added to meet the third level of protection set by the NIJ, and so on. Hence the manufacturers stocking requirements can be simplified by making up smaller packs of layers which are then combined as

necessary. As described hereinafter this approach to adding layers of protection can also be of benefit to the wholesaler/retailer and the customer.

The layer 32 of chain mail or metal mesh is provided to prevent penetration of sharp instruments such as knives, in stabbing action, but it will also provide some protection against a heavier chopping action from an axe or machete. A metal mesh of small cell size is used. In this embodiment we use a mesh comprising interlocking rings of stainless steel. The rings are formed of 0.8 mm gauge wire, and have a 7 mm diameter. Each ring links with four adjacent rings at the corners of a square. The mesh 32 is attached to the outer surface of the pack 34 by stitching around the outer perimeter of the mesh. The mesh may extend across the full surface area of the pack 34, but in this example is fixed between 5 and 25 mm in from the edge of the pack 34.

Very preferably the mesh is slightly gathered or baggy. This has been found to improve the penetration resistance of the protective pack. The extent of the gather may vary. With a pack or panel size covering the front of the torso, as in this example, the mesh is cut to the same size as the pack 34, 36 and is then fixed to the pack about 10 to 20 mm in from the edge to provide a gather equal to about five to ten per cent of the linear dimension of the mesh panel. Thus, a 400 mm wide panel of mesh has its outer edges fixed about 360 to 380 mm apart. The mesh is fixed to the aramid fiber pack around substantially all of the perimeter of the mesh panel. This ensures that the mesh provides protection over the full area required.

The mesh is fixed by sewing, but may be attached by bonding with a mastic adhesive material, for example. The mesh may be sewn near its edge and then bonded with mastic, or tacked by stitching, at intervals, typically four, across its area to even out the 'sag' of the mesh.

Stitching the chain mail to the very edge of the pack of ballistic fabric layers is undesirable because of fraying of the fabric layers. To ensure coverage up to the edge, the chain mail may be wrapped around the edge

and stitched to the back face of the pack (i.e. the face towards the wearer), a centimetre or so in from the edge.

If the chain mail is attached with mastic material, then the mastic may be applied close to the edge of the pack. We have found that a BETAFILL 10210 Mastic, from Granit of Essex, is suitable. Mastic materials do not adhere easily to the aramid fibre layer, probably because the fibre surface has no inherent charge on it. Thus, when mastic is used to adhere the chain mail we prefer to add a layer of polyester weave to the pack of aramid fibre layers. Preferably the polyester layer covers the front, outer surface of the pack and is wrapped around the edges of the pack. The polyester layer is then sewn to the rear of the pack. This will contain any fraying of the ballistic fibre layers.

The ballistic resistance of aramid fibre is reduced when wet and so the outer cover is of waterproof material.

The embodiment of Figure 2e shows schematically a basic protection pack arranged to meet a lowest level of ballistic penetration resistance.

Increased levels of protection can then be met by adding further layers or packs of ballistic resistant textile such as a pack 36 (see figures 2a to 2 d) of woven aramid fibre. The pack 36 is shown as being incorporated within the outer cover 30, but as explained herein, the additional pack 36 etc. could be provided in a separate cover.

As illustrated schematically in Figure 2b, we also contemplate adding a pack of woven ballistic nylon layers 42. This is attached to the rear of the pack 36, nearest the wearer, by stitching at intervals around the edge of the pack. By attaching the ballistic nylon pack only at intervals, there is a slight bagging or pillow effect which, again, appears to provide enhanced protection particularly against knife penetration. The additional layers also provide some trauma protection.

As mentioned above, although the ballistic resistant materials 34,36,42 will slow or stop a bullet, the target can suffer severe trauma due to the dissipated energy or momentum of the bullet. The potential trauma

is indicated by terms of the back face deformation of the garment, which is measured, for example, by placing the garment against a layer of a stipulated clay or silicone, such as PLASTILINA, and firing into the garment under defined conditions. The resultant maximum indentation should be less than a specified amount, as high as 44 mm for some US standards, but as low as 20 mm for some European standards.

We provide a trauma reduction pack which may be incorporated within the cover 30, but preferably is provided outside the cover 30 and within the outer cover 16.

Figure 2c illustrates a protective pack incorporating a trauma reduction pack 44 which comprises a layer of LDPE sheet 46 of 0.5 mm thickness and a layer 48 of impact absorbent small celled foam material under the trade name MEMORY(RTM) V9 by ASTRON Elastomerproduckte GmbH of Vienna, Austria. The LDPE sheet 46 serves to spread the impact of a bullet etc. A flexible plastics sheet is preferred, preferably less than 1 mm thick, and preferably in the range 0.3 to 0.7 mm thickness. A low density polyethylene sheet provides good load spreading properties whilst being light and flexible to wear.

The preferred sheet has a density about 0.92 g/10cm^3 (D1505), a tensile strength at breakage of 20 N/m^2, and an elastic modulus of about 290 N/m^2 (D790)

The impact absorbent foam is preferably able to absorb repeated or multiple impacts from a blunt instrument without being permanently deformed. Some foams, such as polystyrene, are permanently deformed and so the impact absorbency is severely diminished after an initial blow. Thus we prefer an impact absorbent foam which recovers substantially all of its volume after an initial blunt instrument impact. A small cell foam is preferred, and a particularly preferred foam is of nitrile/PVC polymer.

The hardness of the foam is preferably from about 5 to 30, more preferably from about 9 to about 15 and preferably about 13 Shore A according to DIN 53505 - BS 903 Part A26 Method N.

The specific gravity is preferably from about 0.1 to about 0.5 g/cm^3, and more preferably about 0.19g/cm^3 according to DIN 53550-BS903 Part A1 - method A). The elasticity is preferably about 4 to about 8%, and preferably about 6% according to DIN 53512.

In the embodiment illustrated in Figure 2d, the trauma resistant pack 44 is positioned outside of the protective pack 28. Additionally this embodiment illustrates the provision of two layers of LDPE 46 and two layers of foam 48 as the trauma packs 44.

The polymer sheet 46 may be adhered to the foam sheet 48 across substantially its full area so that the sheets move or flex as a unit.. However, it is preferred not to adhere the polymer and foam sheets 44, 46 as this reduces flexibility of the pack. Thus, the sheets are preferably tacked together by stitching, spot welding or gluing or the like to allow at least some relative movement and increased flexibility. The sheets need not be secured directly to each other, however, provision should be made in the finished garment to ensure that the various protective layers 32 to 48, remain properly positioned in the garment. Hook and loop fasteners are preferably provided to locate layers relative to one another (except where they are stitched together) and to locate the pack 28 in place within the outer cover 16.

Shown in Figure 2e is an embodiment in which a thin flexible plastics sheet 50 is provided at the exterior surface inside the protective pack 28, at the outer surface relative to the wearer, to prevent penetration by a needle.

The preferred plastics sheet is a PVC sheet of thickness 0.15 to 1.0 mm. Preferably multiple layers are used, but preferably giving a total thickness less than about 1.0 mm. Preferably four sheets of thickness about 200 microns or five sheets of thickness about 150 microns are used. A layered or fishscale structure may be used to allow greater flexibility. The sheets may be tacked in place over the mesh 32, or substantially fill the pocket formed by the cover 30. The sheet may be placed outside the pack 28, in the pocket formed by the outer cover 26.

It is preferred that the plastics sheet be outward of the ballistic fibre packs relative to the wearer, because a needle penetrating the packs is supported by them and so less easily deflected.

Other systems for providing protection against needle penetration are contemplated. A composite of polyaramid with carbon or resin can receive an electrostatic coating of thermosetting plastics material. A metal or plastics mesh, which may be extruded or woven, may have a continuous layer or sheet of plastic electrostatically coated on to it. Yet another variation is to form a plastics layer, again preferably by electrostatic coating, on a metal mesh formed by punching apertures in a metal sheet and drawing the sheet.

As mentioned above, the trauma reduction pack 44 reduces the flexibility of the garment, as well as adding to its bulk. We have realised that trauma reduction need not be provided over the full area of the torso which is to be protected by the pack 28. A function of the trauma protection pack is to dissipate the force of a blow sufficiently to prevent immediate disablement of the wearer, and to protect vital organs which lay close to the surface of the body unprotected by muscle layers, for example. Thus, we prefer that the trauma reduction pack be less extensive than the protective pack 28. Figures 3a and 3b illustrate front and back views of the upper torso, showing the location of vital organs and the preferred coverage of the trauma reduction pack.

Figures 3a and 3b show schematically the location of some of the vital organs for which trauma protection is desirable. As illustrated, the basic protective pack 28 extends over a large area of the upper torso, but the trauma protection pack 44 is shaped to cover only the vital organs, in particular the spine, heart, liver, lungs, kidneys and spleen. It is of course, important to ensure good location of the trauma protection pack 44 when it is shaped to cover only specific areas.

As mentioned above, we have found that it is not necessary to provide the ballistic textile material as a single tightly formed pack, and it is

possible to provide the manufacturer, and importantly the user, with a system which can be readily adapted to different safety requirements. Thus, a basic level protection pack may correspond to the pack illustrated in Figures 2a and 2b, but with only the single ballistic fibre pack 36. To provide a next higher level of protection, the manufacturer or user may carry a stock of packs 34. For the manufacturer, these may be incorporated in the outer cover 28 before sealing. For the user, they may be provided in their own waterproof cover 28, and then inserted into the outer cover 16. Further ballistic packs 34, 36 or 42 may be added in this fashion.

Also, the trauma reduction pack 44 may be provided as an optional addition. With a suitable choice of materials, the trauma reduction pack does not need to be in a waterproof outer cover. However, a cover may be preferred to keep the material clean, carry usage instruction, fasteners etc.

To increase flexibility, it has been noted that the thin outer plastics layer may be provided as overlapping sheets or platelets. A degree of articulation may also be provided in the main body of the vest by having overlapping packs 28. Thus a "conventional" pack covering the back area of the wearer may be provided, but the front may comprise a lower pack (or group of packs) covering the stomach or abdomen region and an upper pack or group of packs covering the upper torso or chest area. The upper pack(s) will overlap the lower pack(s) to ensure there is no exposed region, and elasticated straps or panels join the packs to retain them in place but allow flexing at the overlap. This system is particularly suitable for providing protective vests for females as they can be tailored to suit different breast sizes and replacement packs of different size or shape can be provided. This system of overlapping or articulated packs is also particularly suited to protection over the shoulder and neck areas, as well as for more obviously flexed regions such as the hip, elbow and knee joints.

It will be appreciated that the several aspects of the invention described here may be used alone or in combination, and also find utility when combined with prior art arrangements.

Also the invention is not limited to a protective vest. Various aspects of the invention may be applied to garments protecting other areas of the body such the arm or leg.

Figure 4 shows the elements of the invention applied to a waistcoat. The waistcoat 60 has a rear panel 62 and two front panels 64, 66. The panels 62, 64, 66 each contain a protective pack or packs 28, as described above with reference to Figures 1 to 3. The front panels 64, 66 are connected by a zip fastener 68. This obviously provides a region of weakness and so we provide a flap 70 which contains a pack 72 of ballistic resistant textile layers. Preferably at least 10 layers are provided in the flap 70. A hook and loop type fixing 74a, 74b is provided to hold the flap 70 closed across the zip fastener 68.

Figure 5 shows a second embodiment of a waistcoat.

In this embodiment, a single protective pack 28' is arranged to extend fully across the front of the wearer. The pack 28' is held on the inside of the left front breast panel 66' covering the heart of the wearer. The pack 28' may be slid sideways into a pocket (not shown) formed in the panel 66'. It is held in place, by hook and loop fasteners 72a, 72b provided respectively on the panel 66' and the pack 28'. The other panel 64' may simply be formed by relatively stiff covering material. To close the waistcoat, the panel 64' is laid across the pack 28'. Loop fastenings 72a on the inside of panel 64' are provided to cooperate with hook fasteners 72b on the pad 28' to ensure it is held in place, and a zip fastener 68' closes the waistcoat 60'. Preferably a flap 70' of ballistic material is still provided even though a pack 28' sits behind the zip fastener 68'. Impact of a bullet directly on a fastener 68' might result in shards penetrating the protective pack 28'. By holding the pack 28' on the inside of the left panel 66', the waistcoat still provides a degree of protection of the heart region even if the waistcoat is left open for some reason.

CLAIMS:

1. A protective garment comprising a plurality of textile layers resistant to penetration by a projectile such as a bullet and, on the outer surface of the plurality of layers relative to the wearer, a layer of knife resistant mesh.

2. A protective garment as claimed in claim 1, wherein the mesh is attached to the textile layers so as to be gathered or baggy.

3. A protective garment as claimed in claim 1 or 2, wherein the mesh is of metal or ceramic material.

4. A protective garment as claimed in claim 1, 2 or 3, wherein the mesh comprises interengaged endless links.

5. A protective garment as claimed in any one of claims 1 to 4, wherein the mesh is attached at its outer perimeter to the fabric layers.

6. A protective garment as claimed in claim 2, wherein the mesh is attached to the fabric layers so that in at least one direction the mesh covers an area which is equal to about 95 % or less than the area covered by the mesh when stretched out.

7. A protective garment as claimed in claim 6, wherein the mesh is gathered so that the overall area covered by the mesh is about 75 to about 90 per cent of the area covered by the mesh when stretched out.

8. A protective garment as claimed in any one of claims 1 to 7, wherein two or more packs of ballistic resistant textile layers are provided, each pack comprising a plurality of ballistic resistant textile layers which are tightly secured together.

9. A protective garment as claimed in claim 8, wherein the packs are loosely secured together.

10. A protective garment as claimed in any one of claims 1 to 9, wherein a trauma reduction pack is provided.

11. A protective garment as claimed in claim 10, wherein the trauma reduction pack comprises a layer of small-celled foam which substantially fully recovers after impact by a blunt instrument, and a layer of flexible plastics sheet.

12. A protective garment as claimed in claim 11, wherein the foam and the plastic sheet are not secured to each other or are secured to allow some relative movement therebetween.

13. A protective garment as claimed in claim 10, 11 or 12, wherein the plastics sheet is low density polyethylene.

14. A protective garment as claimed in any one of claims 10 to 13, wherein the foam has a hardness of about 13 Shore A.

15. A protective garment according to any one of claims 10 to 14, wherein the foam has an elasticity of about 6%.

16. A protective garment as claimed in any one of claims 10 to 15, wherein the trauma reduction pack is not co-extensive with the ballistic resistant textile layers.

17. A protective garment as claimed in any one of claims 1 to 16, comprising:

a garment outer cover adapted to be worn by a user, the cover having one or more pockets for housing a pack of protective material,

a first pack of protective material adapted to meet a first standard for body armour,

a further pack or packs of protective material adapted to meet, alone or in combination with the first pack of material, a second, higher standard for body armour.

18. A protective garment as claimed in any one of claims 1 to 17, further comprising a thin plastics layer, preferably a polyvinylchloride layer, to resist needle penetration.

19. A protective garment as claimed claim 18, comprising a plurality of thin layers of plastics having a total thickness less than 1.0 mm.

20. A protective garment manufactured by dividing into two or more packs a number of ballistic resistant fabric layers providing a predetermined resistance to penetration, each pack comprising a plurality of ballistic resistant textile layers which are tightly secured together.

21. A protective garment as claimed in claim 20, wherein the packs are loosely secured together.

22. A protective garment as claimed in claim 21, wherein the packs are secured together at their perimeter.

23. A protective garment having a trauma reduction pack which comprises a layer of small-celled foam which substantially fully recovers after impact by a blunt instrument, and a layer of flexible plastics sheet.

24. A protective garment as claimed in claim 23, wherein relative movement between the plastics foam and the plastic sheet is provided for.

25. A protective garment as claimed in claim 23 or 24, wherein the plastics sheet is low density polyethylene.

26. A protective garment as claimed in claim 23, 24 or 25, wherein the foam has a hardness of from about 9 to about 30, preferably from about 11 to about 15, and more preferably about 13 Shore A.

27. A protective garment as claimed in any one of claims 23 to 26, wherein the foam has a specific gravity of from 0.1 to 0.5 g/cm^3, preferably about 0.19 g/cm^3.

28. A protective garment according to any one of claims 23 to 27, wherein the foam has an elasticity of from about 4 to about 8%, and preferably about 6%.

29. A protective garment comprising an outer cover containing one or more ballistic resistant layers and a trauma reduction pack, wherein the trauma reduction pack covers a smaller area than the penetration resistant layer.

30. A protective garment as claimed in claim 29, wherein the trauma reduction pack covers only vital organs of the body.

31. A protective garment, comprising:

a garment outer cover adapted to be worn by a user, the cover having one or more pockets for housing a pack of protective material, and

a plurality of packs of protective material, wherein selected ones of the packs of material are housed in the outer cover, a pack or combination of packs meeting a desired standard of protection.

32. A protective garment as claimed in claim 31, wherein a first pack comprises a plurality of ballistic resistant textile layers and meets a first protection standard, and a second pack comprises a plurality of ballistic resistant textile layers, and the two packs combined meet a second protection standard.

33. A protective garment as claimed in claim 31 or 32, including a pack which incorporates a trauma reduction material.

34. A protective garment comprising a thin sheet of plastics material to prevent penetration by a hypodermic needle or the like.

35. A protective garment as claimed claim 31, comprising a plurality of thin layers of plastics having a total thickness less than 1.0 mm.

36. A protective garment as claimed in claim 19 or 34, wherein the sheet of plastics material is formed by coating a substrate.

37. A protective garment as claimed in claim 36, wherein the substrate is coated by electrostatic deposition.

38. A protective garment as claimed in claim 36 or 37, wherein the coating is a thermosetting plastics material.

39. A protective garment having a zip fastener, wherein a flap incorporating ballistic resistant textile layers is provided for overlaying the zip fastener.

40. A protective garment as claimed in any one of claims 1 to 39, in the from of a waistcoat.

41. A protective garment as claimed in claim 40, wherein the garment includes a protective pack which extends across both front panels of the waistcoat.

42. A protective garment as claimed in any preceding claim, including two or more packs or layers protective material which overlap and are connected together to allow articulation between them.

43. A protective garment as claimed in any preceding claim wherein a pack or layer of protective material is shaped to fit a body contour.

44. A protective garment as claimed in claim 43, wherein the shaping is by providing darting in the material.

The Patent Office

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Application No:	GB 9822127.8	**Examiner:**	Ben Micklewright
Claims searched:	1-19,36-38,40-44	**Date of search:**	3 December 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): A3V

Int Cl (Ed.6): F41H (1/02)

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X,Y	WO 97/24574	(SAFEBOARD) See e.g. page 2 line 46 to page 3 line 20, the abstract and figure 3	X: 1-3,5 Y: 8-13,17 40-44
X,Y	WO 91/06821 A1	(LEE) See e.g. page 1 lines 29-35, page 3 lines 23-31 and the figures	X: 1-3,5 Y: 8-13,17 40-44
X,Y	US 5 472 769	(GOERZ) See e.g. column 4 line 49 to column 5 line 5 and figures 5-8	X: 1-7,10,11 Y: 8-13,17 40-44
Y	US 5 327 811	(PRICE) See e.g. column 2 lines 23-30, column 4 lines 6-8 and lines 51-67, column 5 lines 62-65	8,9,17
Y	US 4 660 223	(FRITCH) See e.g. figures 1-3 and column 2 lines 51-61	42
Y	US 4 507 802	(SMALL) See e.g. column 3 lines 44-51, column 5 lines 4-11 and the figures	17,40,41
Y	US 4 413 357	(SACKS) See e.g. column 2 lines 9-15, line 58 to column 3 line 24 and the figures	8-13, 43,44

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

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Category	Identity of document and relevant passage	Relevant to claims
X,Y	US 3 971 072 (ARMELLINO) See e.g. column 4 lines 18-27	X: 1,3,5 Y: 8-13,17 40-44

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Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.